Fiber Optic Helmet Mounted Display

Captain John A. Brunderman, Project Manager 2743, prepared the attached briefing for the AIAA Conference, 18-30 Apr 87, at NASA Langley. There were no proceedings published and no handouts given.

The briefing covers the capabilities, current status and future plans of the Fiber Optic Helmet Mounted Display (FOHMD) being developed under a joint US/Canada cost-sharing program. The technology is intended to fill a gap that exists in simulator visual displays. The technology is not classified and has been briefed a number of occasions throughout the simulation industry.

This briefing was given previously to the joint US/Canada Working Group who supports this project. It contains a pictorial description of the design concept, a table of training requirements versus display performance, the current status of the development effort, recognized technical problems with improvements underway to eliminate them, and an anticipated schedule for demonstration. The briefing follows the viewgraphs and describes their intent in slightly more detail.

SLIDE 1 – INTRO: Self explanatory

SLIDE 2 – OVERVIEW: A listing of the items to be discussed.

SLIDE 3 – FIBER OPTIC HELMET MOUNTED DISPLAY – JAN 87: Drawing gives an overview of the current components making up the simulation system. It uses two Singer DIG 1's to provide four channels of digital imagery to the display device. The signals are fed through a video blending circuit, which tapers each channel's common edges for later blending of inset and background imagery, to a set of four GE light valves, one for each channel. The light valves convert their separate electronic impulses into visual images and project them through a set of combiner optics developed by Farrand to fuse the inset and background channels. This fused image is then piped into the appropriate fiber optic cable, made by Schott Optical, and delivered to the helmet, where it is displayed to the pilot with a second set of optics, manufactured by Farrand. These optics provide a wide instantaneous field of view to the pilot and have a see-through capability for viewing cockpit instrumentation and HUD symbology. An optical head tracker, developed by CAE, and an infrared eye tracker, developed by SRD, are used to feed the head and eye positions to a special controller box which in turn drives the video blending and eye slaving servo motors in the optics, and tells the image generator what part of the world to produce. This enables the pilot to have the same field of regard as that available in an F-16. The master host computer, a Gould SEL 32/9780 programmed by Singer/Link, uses the inputs from the F-16C cockpit, also build by Singer/Link, to compute the proper aerodynamic response, drive the instrumentation and update the IG. An instructor/operator station developed by CAE is used to initialize scenarios, monitor missions, and control the entire simulation.

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14. ABSTRACT **The briefing covers the capabilities, current status and future plans of the Fiber Optic Helmet Mounted Display (FOHMD) being developed under a joint US/Canada cost-sharing program. The technology is intended to fill a gap that exists in simulator visual displays. The technology is not classified and has been briefed a number of occasions throughout the simulation industry. This briefing was given previously to the joint US/Canada Working Group who supports this project. It contains a pictorial description of the design concept, a table of training requirements versus display performance, the current status of the development effort, recognized technical problems with improvements underway to eliminate them, and an anticipated schedule for demonstration. The briefing follows the viewgraphs and describes their intent in slightly more detail.**						
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SLIDE 4 – DESIGN CONCEPT: This slide breaks out the display path in slightly more detail and I will only discuss items not covered on the previous slide. The four channels coming from the IG consist of two low resolution background channels (82 x 64 deg field), and two high resolution inset channels (25 x 19 deg field), one set for each eye. The light valve projectors are rated at 1000 lumens each and produce a room brightness display. This diagram shows the position of the eye tracking servo optics (E.T.S.O.) in the path. It also lists the components which make up the optical chain.

SLIDE 5 – REQUIREMENTS VS PERFORMANCE: A number of requirements exist for a visual display in a tactical training system. This slide attempts to match the capabilities of the FOHMD with those requirements. The FOHMD has a 360 degree field of regard with a 126 degree instantaneous field of view (FOV). Within that FOV is a 35 deg high resolution, eye-slaved inset rated at 1.5 arc min per line pair (approx 20/30 equivalent). The display delivers an image to the eye of 80-foot lamberts of brightness (approx equal to the average light available on a cloudy day), at a contrast ratio of 30 to 1. The display has true stereoscopic vision available within the 40 deg overlap region for binocular cueing tasks. It uses only four IG channels and takes up less space than other comparable full field-of-regard displays. In all, the Fiber Optic Helmet Mounted Display goes a long way toward meeting the tactical training requirements for visual display devices.

SLIDE 6 – FIELD-OF-VIEW PLOT: This slide shows the relative coverage of the instantaneous FOV in the display with respect to the total instantaneous FOV available to the pilot in the cockpit wearing a conventional helmet along with that available to the eye with no obstructions.

SLIDE 7 – CURRENT STATUS: The current system is configured for head tracked operations only, with the high resolution inset fixed in the center of the overlap region. The optics give a 126 x 60 deg field of view with a see-through capability to monitor conventional cockpit instruments and any HUD/MFD symbology. The display is integrated with a functional F-16C cockpit and a Singer DIG I image generator at Williams AFB AZ. Human factor studies are underway now to provide input into future design improvements.

SLIDE 8 – CURRENT PROBLEMS/ISSUES: We recognize a number of areas where improvements can be made in the system. The instantaneous FOV may be too narrow for some tactical tasks. There is a visible fiber structure in the cables that detract from image quality. The eye tracker has not met our performance/reliability expectations. One reason is that the basic eye tracking problem is made much more difficult because of the high brightness of the display. Helmet fit and stability is extremely important in this display, but presently is somewhat uncomfortable over lengthy periods of time. In addition, because of this requirement, we have yet to develop an acceptable generic demonstration helmet.

SLIDE 9 – IMPROVEMENTS UNDERWAY: Work is underway to correct the deficiencies noted above. We are improving the optics to allow for an instantaneous field of view of 160 degrees. Development is continuing on fiber optic cables using formatting techniques that will significantly reduce the visible fiber structure. In addition, we are pursuing a dynamic multiplexing approach (vibrating both ends of the cable in sync), to totally mask any remaining structure while also improving resolution. The optical path is being redesigned to incorporate multiplexing, reduce weight, and to fold upward, which will reduce inertia. CAE is pursuing a major eye tracking redesign to overcome many of the problems encountered on this display. We are optimistic they will succeed. Tangential to the display development is work on a modular distributed microprocessor-based host computer to run the entire simulation. CAE is designing this system to replace the large mini-computer currently on line. Finally, we plan on conducting transfer of training studies to fully determine the training utility of this device for transition to the user community.

SLIDE 10: SCHEDULED MILESTONES: This chart gives the estimated dates for the various stages of development discussed above. The Advanced Visual Technology System (AVTS), referenced in the fifth milestone, is a prototype advanced image generator comparable to the GE CompuScene 4. The final two-ship demonstration will simulate two F-16Cs with FOHMDs driven by AVTS.

SLIDE 11 – NEXT GENERATION: This chart shows the areas of improvement we want to address in the next generation developments. We plan on a two-stage effort to meet out objectives while minimizing the risk along the way. Our primary objective is to further reduce the IG requirements from the original four-channel system to two-channels using binocular overlap replication circuitry for the background channel and having the other channel supply both insets. As an ancillary but extremely important effort, a high brightness CRT-based projector system with a mini-raster capability will be developed thus eliminating much of the mechanical and optical complexity of the current system. Phase II will attempt to further reduce IG requirements by optimizing pixel distribution with respect to human visual system requirements. Secondary objectives for this next generation will be continued optics, tracker and helmet development with the emphasis being on reducing system complexity, cost, and operational support requirements.

SLIDE 12 – ROADMAP: The current FOHMD contract will be completed by FY88 with the delivery of the 160-degree, 4-channel system. An early FY89 contract start date is anticipated for the next generation system with the Phase I product delivered 4Qtr 90 and Phase II finished by 4Qtr 91. This reduced support system should successfully transition to deployment in the FY93 time frame.

FIBER OPTIC HELMET MOUNTED DISPLAY

RESEARCH AND DEVELOPMENT

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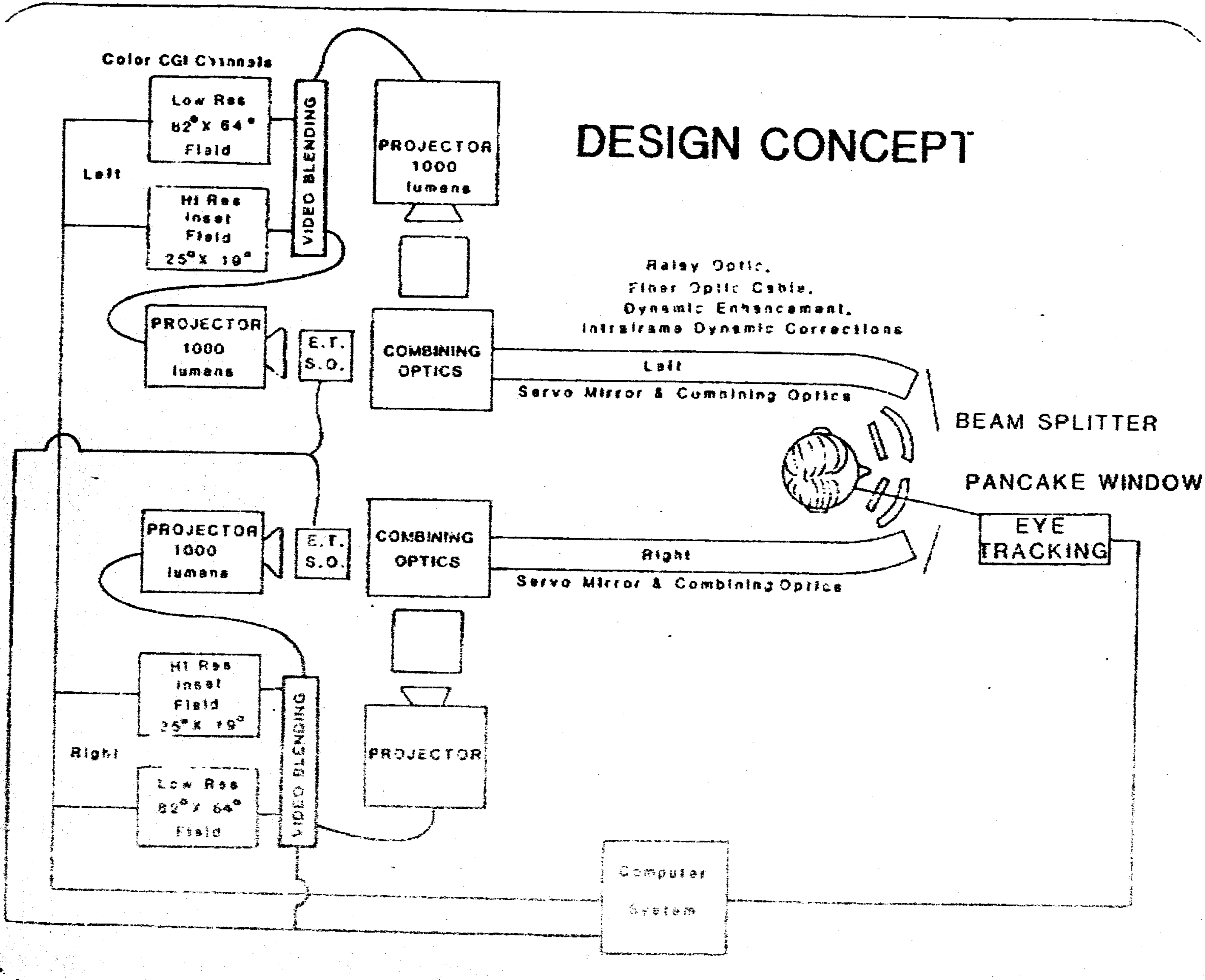
FIBER OPTIC HELMET MOUNTED DISPLAY
OVERVIEW

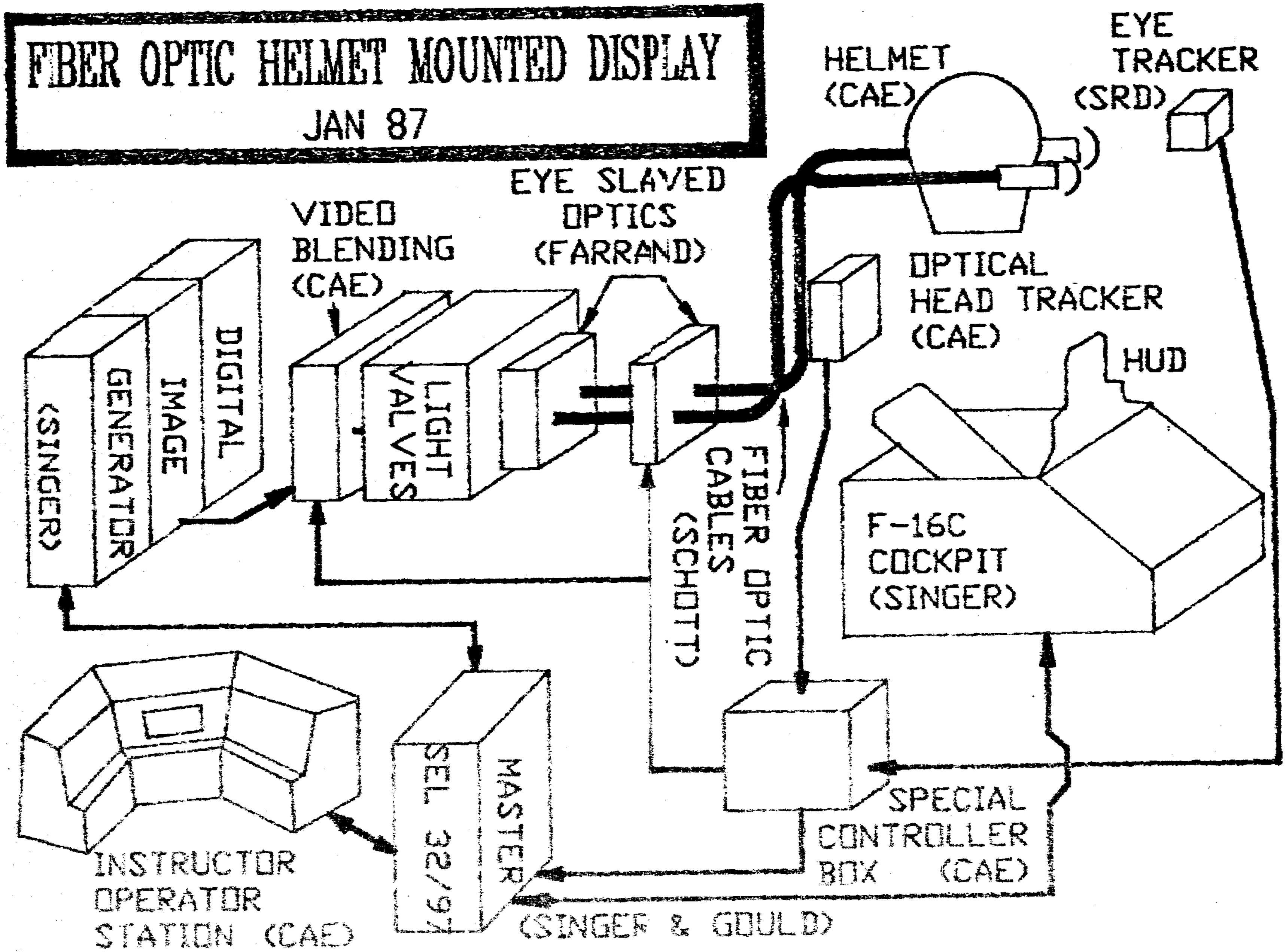
- O DESIGN CONCEPT
- O PERFORMANCE
- O CURRENT STATUS
- O CURRENT PROBLEMS/ISSUES
- O IMPROVEMENTS UNDERWAY
- O NEXT GENERATION ADVANCEMENTS

DESIGN CONCEPT



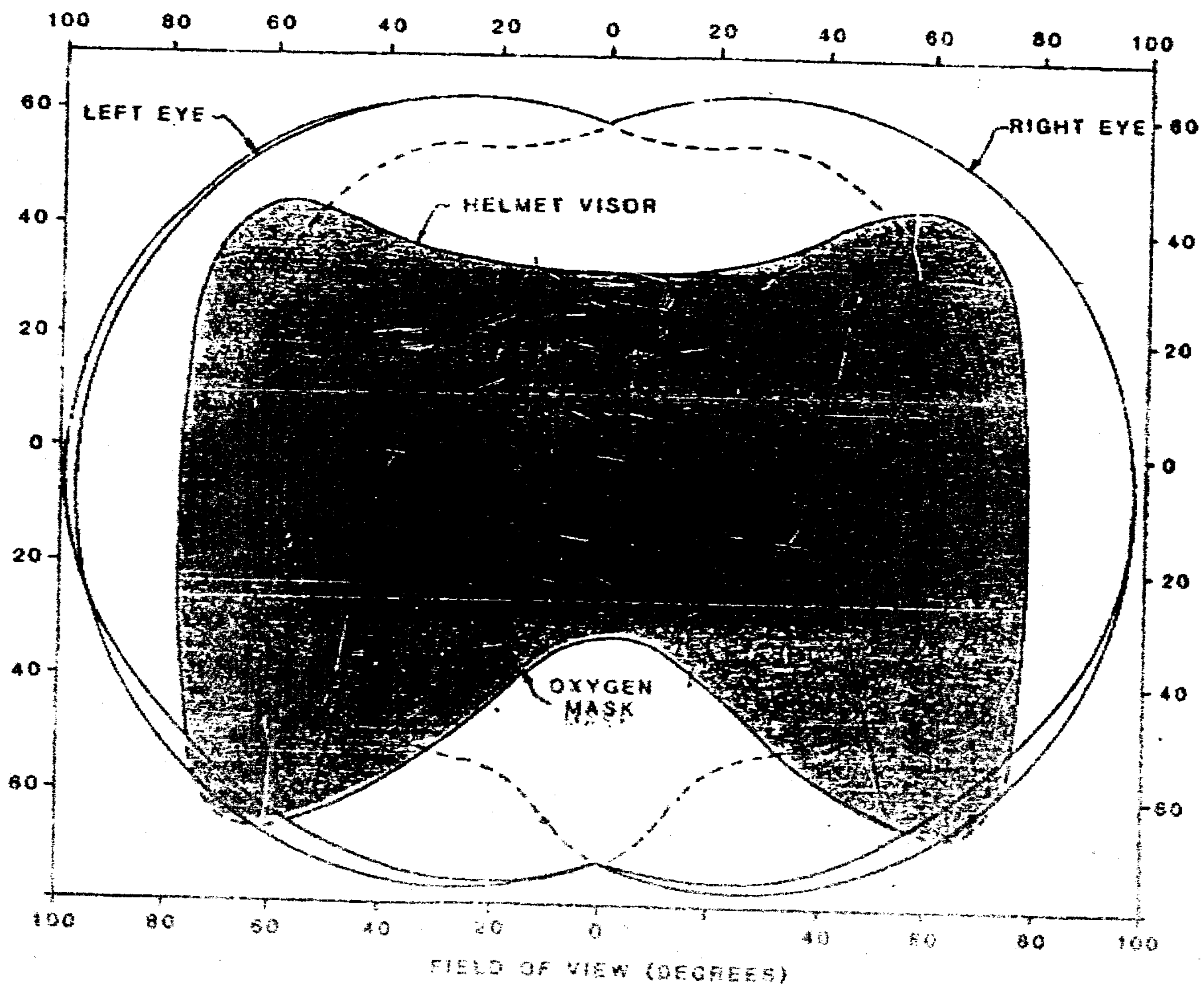
FIBER OPTIC HELMET MOUNTED DISPLAY

JAN 87



TRAINING SYSTEM REQUIREMENTS ⟹ FIBER OPTIC HELMET MOUNTED DISPLAY PERFORMANCE

TRAINING SYSTEM REQUIREMENTS	FIBER OPTIC HELMET MOUNTED DISPLAY PERFORMANCE
• FIELD OF VIEW ADEQUATE FOR AIR-TO-AIR TRAINING	• 360 DEG TOTAL AVAILABLE 126 DEG INSTANTANEOUS 25 DEG HIGH RESOLUTION
• TARGET VISIBILITY SUFFICIENT FOR NORMAL RANGE DETECTION AND RECOGNITION	• 1.5 ARC MIN HIGH RESOLUTION EYE SLAVED INSET • 80 FOOT LAMBERT BRIGHTNESS • 30:1 CONTRAST RATIO
• TERRAIN CUEING FOR LOW LEVEL FLIGHT	• 8000 EDGES IN FOHMD DISPLAY COMPARABLE TO 60,000 EDGES IN 360 DEG WRAP AROUND VISUAL
• DEPTH CUES FOR TACTICAL FORMATION FLIGHT AND AERIAL REFUELING	• TRUE STEREOSCOPIC VISION FOR BINOCULAR CUEING
• AFFORDABILITY	• REDUCED IMAGE GENERATOR CHANNELS AND PROJECTOR REQUIREMENTS
• PORTABILITY	• MINIMAL FACILITY REQUIREMENTS



LEFT EYE
RIGHT EYE
HELMET VISOR
OXYGEN MASK
FIELD OF VIEW (DEGREES)

FIBER OPTIC HELMET MOUNTED DISPLAY
CURRENT STATUS

- 0 HEAD TRACKED OPERATION
- 0 SEE-THROUGH OPTICS
- 0 HUMAN FACTOR STUDIES UNDERWAY
- 0 INTEGRATED WITH F-16C COCKPIT & SINGER DIG
- 0 126° x 60° INSTANTANEOUS FIELD-OF-VIEW

FIBER OPTIC HELMET MOUNTED DISPLAY
CURRENT PROBLEMS/ISSUES

- LIMITED INSTANTANEOUS FIELD-OF-VIEW
- VISIBLE FIBER STRUCTURE
- POOR EYE TRACKER PERFORMANCE/FIDELITY
- LACK OF ADJUSTABLE DEMONSTRATION HELMETS
- POOR HELMET COMFORT & FIT

FIBER OPTIC HELMET MOUNTED DISPLAY IMPROVEMENTS UNDERWAY

- WIDEN INSTANTANEOUS FIELD-OF-VIEW TO 160°
- REDUCE FIBER STRUCTURE VISIBILITY
- FURTHER REDUCE HELMET WEIGHT/INERTIA
- IMPROVE EYE TRACKING HARDWARE, SOFTWARE AND PREDICTION ALGORITHMS
- INTEGRATE MODULAR MICROPROCESSOR BASED HOST COMPUTER
- CONDUCT TRANSFER OF TRAINING RESEARCH

FIBER OPTIC HELMET MOUNTED DISPLAY
SCHEDULED MILESTONES

□ EYE-SERVOED OPTICS	3 QTR 87
□ DYNAMIC MULTIPLEXING	4 QTR 87
□ HEAD/EYE TRACKED SYSTEM DEMO	1 QTR 88
□ FULL INSTANTANEOUS FOV OPTICS	2 QTR 88
□ FOHMD DEMO DRIVEN BY ADVANCED VISUAL TECHNOLOGY SYSTEM	1 QTR 89
□ 2-SHIP AIR-TO-AIR DEMO USING FOHMD'S	2 QTR 89

FIBER OPTIC HELMET MOUNTED DISPLAY
NEXT GENERATION

	PHASE I (2-CHANNEL)	PHASE II (1-CHANNEL)
MINIMIZE IG REQUIREMENTS	BINOCULAR OVERLAP CIRCUITRY	CUSTOMIZE TO HUMAN VISUAL SYSTEM REQTS
REDUCE MECHANICAL COMPLEXITY & SIZE	DEVELOP HIGH BRIGHTNESS CRT	SYSTEM PACKAGE HEAD/EYE TRACKER & OPTICS
ADDRESS OPERATIONAL ACCEPTABILITY	DEVELOP GENERIC HELMETS	ENHANCE CUSTOM HELMET COMFORT/ FIT & APPEARANCE
ADVANCE LIMITING TECHNOLOGIES	EYE TRACKER FIBER OPTIC BUNDLES	

FIBER OPTIC HELMET MOUNTED DISPLAY
ROADMAP